DRAINAGE OF SOUTHERN INDIANA.

INTRODUCTION.

Area to be discussed.—Only those features of the drainage of southern Indiana which are dependent upon geological structure and are not controlled primarily by glacial drift will be discussed. This limits the discussion to that portion of the state that lies south of a line running from Indianapolis east to the Ohio state line, and from Indianapolis southwestward along the course of West White River to the mouth of that stream.

While the eastern tributaries of the West White River from Indianapolis to the mouth of Bean Blossom Creek, and the tributaries of East White River in northern Shelby and Johnson counties, owe their positions largely or entirely to the drift,[1] the main streams of the area referred to are controlled by the underlying strata.

The driftless and drift-covered regions.—The driftless region of southern Indiana is an irregularly triangular area, with the base of the triangle along the Ohio river, reaching from Mount Vernon to a point a few miles above Jeffersonville, a direct distance of 135 miles, and the apex of the triangle near the northeast corner of Monroe county, 135 miles northeast of Mount Vernon and 85 miles slightly west of north from Jeffersonville. All other portions of the area under discussion are, or have been, more or less covered by the drift.

Over most of the region both directly east and directly west from the unglaciated area the covering of drift is comparatively thin. In the region to the east especially, the drift covering is rarely as much as 100 feet thick, and many of the streams have cut down through it and into the underlying rocks. In some cases these streams occupy preglacial channels; in others the

[1] These small streams are not included in the following remarks regarding the drainage. Neither are the streams between West White and Wabash rivers discussed, although those streams are shown on the map, Plate VI.

valleys have been cut out entirely since glacial times, leaving the drift in remnants only upon the hilltops and uplands.

Effect of the structure in the region thinly covered by the drift.— The thin mantle of drift that covers that portion of the state east of the driftless area lies on strata that dip gently to the southwest, and on an old surface whose general contour prior to the deposition of the drift was similar to that of the present time. Therefore, while the minor lines of drainage have been modified by the drift, the general south and southwest drainage of the country is such as would be logically developed in a country of such combinations of hard and soft southwestward dipping strata as southern Indiana possesses, and it is practically the same now as it was in preglacial times.

The series of strata that control the topography and drainage.— There are in southern Indiana three thick series of shale beds, between which are groups of harder and more resisting limestones and sandstones. In going from east to west across the state these groups are as follows: (See the numbers on the cross sections shown on the accompanying drainage map, Plate I.) (1) the Hudson River shales, along the east side of the state; (2) the resisting Niagara limestone, and limestones at the base of the Devonian; (3) the New Albany and Knobstone shales, all soft and easily eroded beds; (4) the Knobstone sandstones and overlying Carboniferous limestones, which are in turn overlain by the sandstones at the base of the Coal-measures;[1] (5) the soft Coal-measures, shales, and sandstones of the west side of the state.

Postglacial and preglacial topography.—The softer groups of strata, viz., 1, 3, and 5, form drainage areas (discussed below as the eastern, central, and western drainage areas respectively) that are more or less separate from each other in each case, while the harder groups, 2 and 4, form the highlands or watersheds between those areas.

[1] The Lower Carboniferous limestones are eroded more easily than the beds lying both east and west of them, but their denudation has not been so great as to form a separate drainage basin in the area underlain by them.

The strata that form the different drainage areas and the watersheds between them in the southern part of the state extend northward under the glacial mantle for some distance beyond the boundary of the accompanying map (Plate I). Therefore it might be expected that the preglacial relief of the country underlaid by those strata was similar to the present relief in the unglaciated area to the south, and this is found to be the case.

The effect of the highlands (formed by groups 2 and 4) where they plow northward under the glacial mantle and lift it up, is noticeable for many miles north of the southern limit of the drift. These buried highlands show that the preglacial topography of the region thus affected was similar in general lines with the present topography which is almost, or entirely, unaffected by the drift at the southern part of the state. Well records show that the central drainage area, or trough, and its eastern rim extended as far north in preglacial time as the north side of Clinton county at least, while the highlands west of it certainly extended as far north as northern Montgomery county.

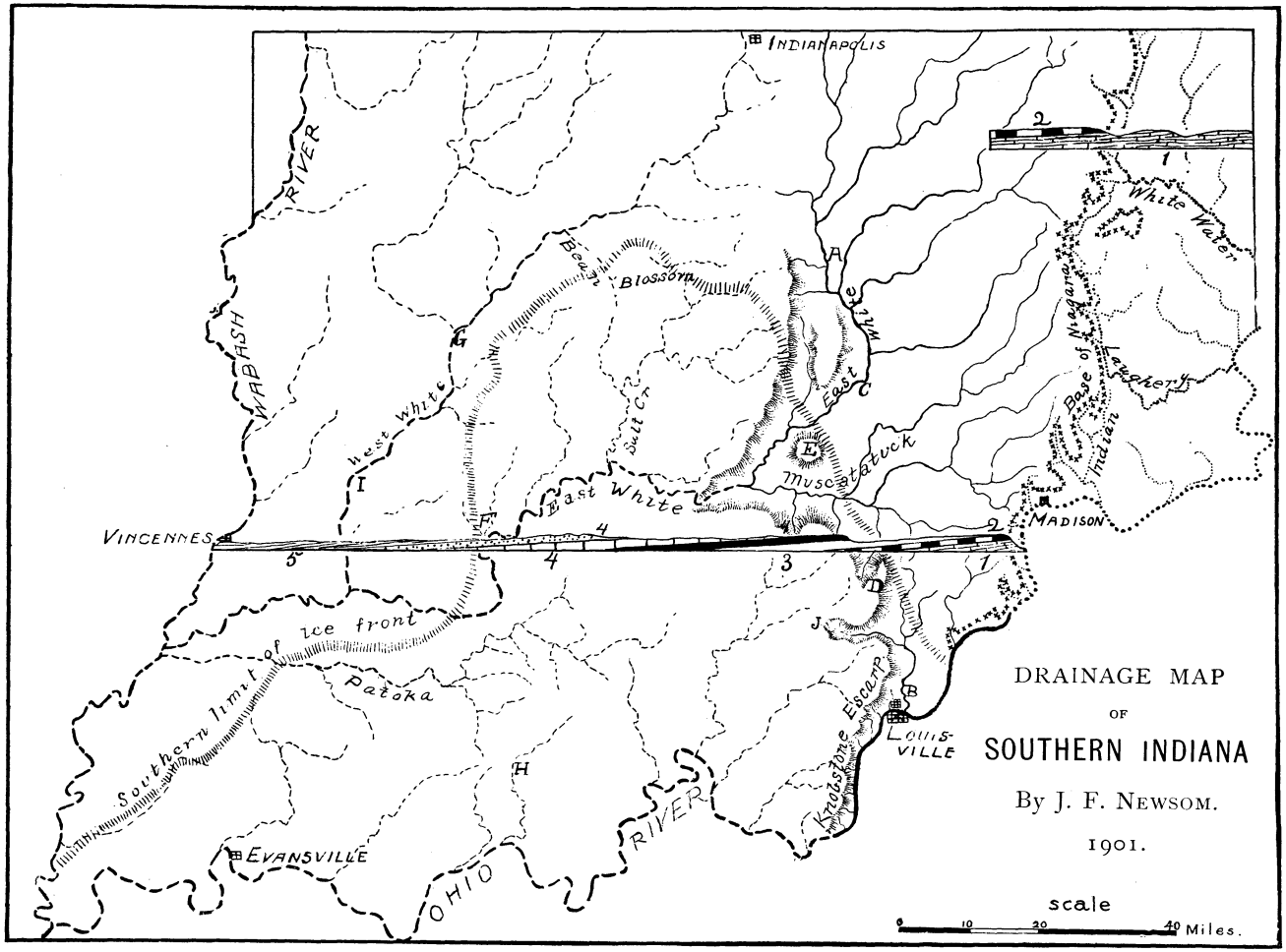
The preglacial topography makes it seem quite probable that the preglacial drainage of this trough was from the eastern rim down the dip of the underlying limestones to the southwest, along lines generally parallel with those of the present streams further south, which are in accordance with, and are controlled by, the geologic structure.

The relations of the different drainage areas and the structure controlling them is shown by the cross sections on the drainage map, Plate VI.

It will be seen, therefore, that the drainage of southern Indiana may be treated in accordance with the groups of strata that control the topography of the region.

Relations of the structure to the drainage.—An examination of the geology in its relation to the drainage shows that there are the three following general drainage areas:[1] (1) the eastern area, covered by rocks of the Hudson River group, and including

[1] These areas cannot be regarded as basins in the proper sense of the term, for each area is drained by many different streams.



Drainage Map of Southern Indiana. The streams of the eastern drainage area are shown by dotted lines, those of the central drainage area are shown by solid lines, and those of the western drainage area are shown by broken lines. (Glacial boundary after Leverett.)

ON CROSS SECTIONS: 5 = Coal-Meas. shales. 4 = Mansfield s's't. / Low. Carb. l's't. / Knobstone s's't. 3 = Knobstone shale. / Devonian shale. 2 = Devonian l's't. / Niagara l's't. 1 = Hudson River shales.

some short streams that rise on the Niagara strata and flow eastward into the Hudson River area; streams of this area are shown by dotted lines on the accompanying map, Plate VI; (2) the central area, covered by the strata between the base of the Niagara and the Knobstone sandstone; streams of this area are shown by solid lines on the accompanying map, Plate VI; (3) the western area, covered by the rocks from the Knobstone sandstone to the top of the Coal-measures; streams of this area are shown by broken lines on the accompanying map, Plate VI. This last area includes the entire southwestern part of the state, and in the eastern part of it the streams have in many places cut down through the limestones and Knobstone sandstones, and into the Knobstone shales. These shales, however, have had no part in the formation of the western drainage area, which, while largely underlain by sandstones and limestones, has its eastern watershed along the Knobstone escarpment within a few miles of the lowest part of the central area.

From each of the watersheds, viz., between the eastern and central, and the central and western areas, the streams that flow east across the dip of the strata are short and have steep gradients, while those that flow west with the dip of the strata, are long and have low gradients.

The larger streams of southern Indiana flow through filled valleys. The depth to which the valleys have been filled varies from a few feet to over one hundred feet.

The different drainage areas will be taken up in their order, and the features of their drainage so far as these depend upon the structure of the underlying rocks will be pointed out. The boundaries between these areas do not follow exactly the outcrops of the strata which form the divides between them, for short streams which belong to the area underlain by Hudson River beds, for example, may rise in the Niagara beds and flow eastward across the dip of those beds for a short distance before entering the area of the Hudson River strata. The same is true of streams belonging to the central basin, which rise at the top of the Knobstone escarpment. On the other hand, the streams

flowing westward sometimes cut down through the hard strata that form the watershed, exposing the underlying softer strata. These facts must be kept in mind in treating the general drainage areas in accordance with the underlying strata.

THE EASTERN DRAINAGE AREA.

While the highest points in the eastern area are almost as high as the watershed at its western side, the streams of this area have cut out valleys from one hundred to four hundred feet deep in the soft Hudson River strata, and the average level of the country is therefore considerably lower than that of the country immediately west. The Hudson River strata are almost horizontal, and with few exceptions the streams flow more or less directly to the Ohio River.

Attention should be called, however, to the upper courses of the Whitewater River,[1] Laughery Creek, and Indian Creek.

The upper courses of these streams are almost in line, they flow nearly due south, parallel with the watershed formed by the Niagara strata, and only a few miles east of that watershed.[2] Excepting those of Indian Creek, the tributaries of these streams that enter from the east and north are comparatively long, while those from the west which rise in the Niagara strata and flow eastward across the dip are short. The main drainage lines and their relations to the controlling beds to the west are shown on Plate VI.

Indian Creek, which drains portions of Ripley and Jefferson counties, flows southward parallel with the watershed at the west, but owing to its shortness and its proximity to the Ohio, this is the course that would be expected of it regardless of the dips of the rocks of the area. It should be noted also that when the Ohio strikes the region of outcropping Niagara limestone at Madison it makes an abrupt turn to the south, and flows south

[1] Whitewater River flows through a preglacial valley below Connersville (Leverett).

[2] It seems probable that these streams have been shifted to these positions by the westward inclination of the beds, although this inclination is very slight.

for about eighteen miles before turning to the southwest and cutting through the Niagara strata.

It is seen, from what has been said above, that the area covered by the Hudson River strata has its main drainage lines parallel with its western rim; that for the most part there are southward flowing streams in the area immediately east of and practically all along this rim, that the tributaries from the west are short, while those from the east are long, and that these features of the erosion may be due to the gentle westward inclination of the strata at the west edge of the area. As the streams approach the Ohio their relations to the watershed at the west are lost, as is seen by the abrupt eastward turn of the Whitewater in northeast Franklin county, and of Laughery Creek in southeast Ripley county.

THE CENTRAL DRAINAGE AREA.

The central drainage area has its eastern watershed formed by the Niagara and Devonian limestones, while its western watershed is formed by the Knobstone sandstones and overlying limestones that form the crests of the hills known as the Knobs.

The east-west profile of this area and its geological relations are shown on that portion of the cross section (Plate I) extending from the Niagara strata to the Knobstone sandstones. The east side of the basin has a gentle slope to the west, while the west side has a steep slope to the east.

The shape of the central drainage area is shown on Plate I, where its streams are shown by solid lines. This area is about fifty-five miles across in its widest part at the north and narrows down until it is less than a mile wide along the Ohio river at the south.

On Plate VI this trough, the axis of which extends from near Edinburg (*A*, Plate VI) slightly east of south to the Ohio River near New Albany (*B*), is shown. From Edinburg to the Ohio the axis is followed approximately by the line of the Jeffersonville, Madison & Indianapolis railroad. The central area, in which the control of the structure upon the drainage is more clearly marked than in either the eastern or western areas, is

made up of two districts: a southern district from which the streams flow directly into the Ohio River, and a northern district, drained by East White River and its tributaries into the Wabash.

The southern district.—After cutting through the Niagara and Devonian limestones the Ohio River flows west and southwest across the southern district until it reaches the strata of the Knobstone group west of New Albany. Here it is deflected to the south and runs close under the bluffs formed by the Knobstone standstone and overlying limestones for about eighteen miles to Taylor township, Harrison county, where it turns to the west and cuts through the Knobstone sandstones and overlying limestones. The southern deflection of the Ohio west of New Albany is very similar to its southern deflection by the Niagara and Devonian limestones just west of Madison. The valley of the Ohio is wider where it crosses the central area, in the neighborhood of New Albany and Louisville, than it is either immediately above or below that locality. This widening of the valley is due to the character and relations of the strata crossed, and in no way indicates that the former size or course of the stream differed greatly from its present size and course. Neither does it indicate that the present river valley at this locality crosses the wide north-south valley of a former large stream.

The streams that enter the Ohio from the west below New Albany are short and have steep gradients. Most of these streams have noticeable down-stream deflections where they enter the Ohio bottom lands, their mouths having been shifted down stream by the deposition of sediments on their up-stream sides.

Above New Albany, Silver, and Fourteen Mile creeks are the principal streams. Silver Creek rises in the Knobstone hills at the south side of Scott county and flows almost due south until it reaches the Ohio above New Albany (*B*). Muddy Fork, one of the tributaries of Silver Creek, rises well over in the Knobstone area near the west edge of Clark county and flows eastward for fifteen miles, across the dip of the strata, before entering the main stream and turning south to the Ohio.

Fourteen Mile Creek rises in the southwestern part of Jefferson county, flows slightly west of south with the dip of the strata and enters the Ohio three miles southeast of Charleston. In its lower portion Fourteen Mile Creek cuts down into the Hudson river strata. Other shorter streams have their sources in the area covered by the Niagara limestones, or the Devonian strata, and flow more or less directly into the Ohio across Hudson river strata. While the general courses of these streams are such as might be expected from the structure of the underlying strata (with the exception perhaps of Muddy Fork of Silver Creek, which rises at *P*, Plate VI, and flows eastward across the dip of the Knobstone strata), the influence of that structure on them is by no means so clearly marked as it is on the streams in the district next to be considered.

The northern district.— It is in the northern district (that portion of the central area lying north of the southernmost cross section, Plate VI), drained by the East White and Muscatatuck rivers, that the effect of the structure upon the drainage is most clearly seen.

The streams that drain the northern district rise for the most part near the watershed which separates this from the eastern drainage area, within a few miles of the main drainage lines of the eastern area, and flow westward down the gentle slope that owes its inclination to the dip of the underlying beds. In their upper portions most of the streams have gradients greater than the dip of the underlying beds and have consequently cut down from newer into older strata. In their lower courses the gradients are less than the inclination of the strata, and the streams pass across successively newer beds.[1] The streams that rise on the western rim of the northern district and flow eastward are short and have steep gradients.

Except for the course of East White River below Seymour

[1] This feature is well shown by the tributaries of Stucker's Fork, in townships 3 north, 8 and 9 east. These streams rise in the Devonian shale area, flow westward with the dip, but cut down through the shale, exposing the underlying limestones for a distance of about six miles, and then, the fall becoming less than the dip of the underlying beds, again pass out into the shale area.

(with which is included the lower course of the Muscatatuck), the drainage lines of the central area are evidently controlled by the geological structure of the country. The effect of the structure upon these streams is well shown in the case of Ramsey Creek — a tributary of the Muscatatuck — which rises just west of Madison near the northeast corner of township 3 north, 9 east, within one and one-half miles of the Ohio River, and 360 feet above that stream. The waters of Ramsey Creek flow into the Muscatatuck, then through East and West White rivers, and the lower Wabash, and finally empty into the Ohio at the extreme southwestern corner of the state, a direct distance of 170 miles from the source which was within one and one-half miles of the Ohio.

From Edinburg to Rockford, a distance of twenty-seven miles, East White River flows southward, parallel to the Knobstone hills and but a few miles east of them. Its tributaries from the west are short and have steep gradients. Those from the east and northeast are long. They rise at the watershed formed by the Niagara strata and flow with the dip down the southwestward slope of the country. The sources of some of the eastern tributaries of East White River are but a few miles west of the Whitewater River — the main drainage stream of the eastern area. The asymmetry of the area drained by East White River is shown by the accompanying drainage map (Plate VI).

One of the most interesting features of the drainage of the central area is the course of East White River below Rockford (*C*, Plate VI). From Edinburg to Rockford this stream flows south along the bottom of the trough east of the Knobstone hills. But while this trough extends on southward to the Ohio River and is apparently the line along which White River could have most easily developed its course, that stream, instead of following the valley (*A*, *C*, *B*, Plate VI) to the Ohio, turns to the west at Rockford and flows through broad bottom lands until it is joined by the Muscatatuck, at the south side of Jackson county. Just below the mouth of the Muscatatuck it enters a comparatively narrow valley, which has been cut down through the Knob-

stone strata, the overlying Lower Carboniferous limestones and the Mansfield sandstone. This valley varies in depth from less than fifty to over two hundred and fifty feet; its length is about seventy-five miles. In width the bottom of the valley (which is filled with alluvium from fifty to seventy-five feet or more), varies from one-half mile to over one mile.

Thus it is seen that instead of carving out a valley along the strike of easily eroded strata, southward from Rockford directly to the Ohio, a distance of fifty miles, East White River turns to the west, flows through a valley cut across hard strata, and finally reaches the Ohio through the Wabash at a point over 150 miles from Rockford.

Two hypotheses may be advanced in explanation of the course of East White River below Rockford.

The first is that the present is approximately the original course of the river; that as this region was first elevated the drainage from the land at the east was deflected to the south parallel with the Knobstone sandstones and behind (*i. e.*, east of them), or else that it shifted itself to this position during its early history; that in the vicinity of the present village of Rockford the drainage turned to the west, cutting across the edges of the strata, and that it deepened its valley in this position as the strata were elevated—gradually establishing itself in approximately the position now occupied across the Knobstone, the Lower Carboniferous limestone, and the Mansfield sandstone. Even though this entire region may have been approximately baseleveled since the orginal drainage was established, elevation subsequent to the baseleveling would have re-established the main drainage along its original lines.

The width of the valley throughout its length from the Muscatatuck to the Coal-measures suggests an age greater than has elapsed since the ice invasion, and makes the above explanation seem probable. The present course of the stream through its gorge below the mouth of the Muscatatuck cannot be explained by stream capture, if it be supposed that East White River originally entered the Ohio in the neighborhood of New Albany. If

it originally entered the Ohio near New Albany, its course below Rockford (*C*, Plate VI) would have been along the strike of easily eroded shales, and directly to the Ohio, a distance of fifty miles from Rockford. It is 150 miles southwest from Rockford to the mouth of the Wabash, through which East White River at present reaches the Ohio, and one-third of this distance is across the strike of resisting limestones and sandstones. It is obvious, therefore, that East White River could not have been captured at or below Rockford by a stream which flowed to the southwest across those hard strata. Moreover, there is no evidence to show that the former course of the stream was directly into the Ohio at New Albany.

Reversion, owing to elevation of the strata to the east and northeast is not regarded as a probable explanation of the lower course of White River, even if it be supposed that the original course of that stream was toward the east or northeast.[1]

The second hypothesis is as follows: It presupposes that prior to the ice invasion, the upper portion of East White River, (viz., east of the present mouth of the Muscatatuck) flowed either north or northeastward, or possibly emptied directly into the Ohio at New Albany—in any event that it flowed generally parallel with the Knobstone hills, east of those hills, and did not cut through them; that short tributaries of this main stream entered from the west, occupying about the courses of the East White and Muscatatuck rivers for fifteen miles above the present junction of those streams, but flowing in the opposite direction; that these short eastward flowing streams formed the triangular *cul de sac* in the Knobstone hills, in the center of which stand the Brownstown Knobs (*E*, Plate VI) with the Silver hills of Scott county (*D*, Plate VI) projecting east of the main line of hills; that west of the Knobstone escarpment the general drainage to the southwest was the same as at the present time[2] and that a

[1] The details of the preglacial drainage north and east from Rockford are obscured by the drift. The general preglacial contour of this part of the country, however, must have been about the same as that of the present time.

[2] In *Monograph XXXVIII, U. S. Geol. Surv.*, Pl. IX, MR. FRANK LEVERETT shows the supposed preglacial westward drainage of this region.

low pass was formed between the westward flowing streams and those flowing eastward which formed the corner of the *cul de sac* above referred to.[1]

During the glacial period the ice passed immediately east of the Knobstone hills in western Bartholomew county, through Jackson, and crowded up against the projecting knobs known as the Silver hills in Scott county (*D*, Plate VI). If the suggested conditions existed at that time, the triangular *cul de sac* in the Knobstone hills would have had its eastern outlet completely shut off by the ice, and the basin thus formed would have filled with water from the melting ice until it poured over the pass into the westward flowing streams; the pass would have been cut down, and finally the stream would have become firmly established in its new course, and into this it would have led the waters of its entire drainage basin as the ice retreated.

The shape of the *cul de sac*, in which the Brownstown hills stand with the eastward projecting Silver hills (*D*, Plate VI), against which the ice was pushed to the south, makes this second hypothesis seem probable. The principal objection to it is found in the general width of the valley of East White River below the mouth of the Muscatatuck. There are no *narrows* in the canyon to correspond with the position of the supposed original divide between the east and west flowing streams. The bottom, or present flood plain, of the valley varies in width from one-half mile to over one mile, and would certainly seem to antedate the ice invasion.

THE WESTERN DRAINAGE AREA.[2]

The main drainage lines of the western area are such as would be developed by the structure of the country, and they

[1] A condition of affairs quite similar to that hypothecated here exists at the present time in townships 1 south and 1 north, 5 and 6 east, where Muddy Fork of Silver Creek forms a triangular valley opening out to the east, while the divide between this stream and Blue River, which flows southwest is quite low. (*J*, Plate I.)

[2] The drainage of southern Indiana, in its relations to the glacial period, is discussed and mapped by LEVERETT in *Monograph XXXVIII, U. S. Geol. Surv.*, p. 97 *et seq.* See also Mr. LEVERETT's discussion, Pt. IV, Eighteenth Ann. Rept. U. S. Geol. Surv., pp. 446–58.

are practically the same at the present as they were in preglacial times. The Knobstone sandstones, with their capping of limestones, rise in an eastward-facing escarpment unbroken, except where cut through by East White River, from the Ohio River at the south side of Harrison county to the northeast corner of Brown county. This escarpment rises from 200 to 400 feet above the lowlands of the central drainage basin immediately east of it, while to the west the country is rolling and descends gradually. The streams rising near the escarpment at the east flow down the gentle slope to the west and finally enter the Ohio, White, or Wabash rivers.

The control of the structure upon the drainage lines of this area is best seen immediately west of the Knobstone escarpment between the East White and the Ohio rivers (Plate VI). North of East White River apparently only the general course of the drainage is controlled by the structure; while in a general way the longest tributaries of the streams are those coming in from the east and northeast, this feature is by no means clearly marked, even in the area underlain by the comparatively hard Lower Carboniferous limestones and Mansfield sandstone.

It is noticeable that the streams of the western area which flow across both the area underlain by the Lower Carboniferous limestones and that underlain by the sandstones at the base of the Coal-measure (Mansfield sandstone) are not deflected as they pass from the limestone into the sandstone area.

The Mansfield sandstone is often massive and forms a rugged topography in the region in which it outcrops, and it might be expected that the streams would be deflected to the north or south by it. However, no such change in the stream courses is to be seen; instead of being deflected they pass directly from the limestone area across the sandstones, through which they have cut deep valleys, until they reach the comparatively flat region underlain by the soft Coal-measures shales at the west side of the Mansfield sandstone.

These conditions lead to the conclusion that the streams

from the land at the east cut directly across the Mansfield sandstone as it was first raised above the water and thus early established themselves in approximately their present courses.

In the region underlain by the soft sandstones and shales of the productive Coal-measures the only systematic arrangement noticeable in the streams is that of their general southwest directions.

Attention should be called in this connection to the sudden southward deflection of the east and west forks of White River, where these streams, after passing through the Mansfield sandstone areas, strike the area of the productive Coal-measures in Martin (*F*, Plate VI) and Greene (*G*, Plate VI) counties. The deflected portions of these streams are in a line with the south course of Anderson River between Spencer and Perry counties (*H*, Plate VI), in the extreme southern part of the state.

The coinciding deflections of these streams are suggestive, as they occur in a line approximately parallel with the position that must have been occupied by the shore line during a portion, at least, of productive Coal Measures times, and the suggestion is made that these streams had their courses turned parallel with the old shore line at that time, and that the streams have occupied approximately that position ever since. In this connection the south deflection of the Wabash near Covington and its due south course from Covington to Terre Haute, parallel to the above-mentioned portions of the two forks of White River and in a line with the southward deflection of West White River northeast of Vincennes (*I*, Plate VI), is of interest and suggests the same causes.

The region underlain by the Lower Carboniferous limestones is pitted with sinkholes and is often almost devoid of surface drainage systems, owing to the cavernous nature of those limestones and the well developed underground drainage in them.

East White River flows from the central across the western area and forms one of the principal streams of the western area.

North of the north line of Monroe and Brown counties the tributaries of West White River flow through glacial débris and

are left out of the discussion, as are also those streams that flow across the productive Coal Measures west of West White River.

SUMMARY.

In summing up the discussion of the drainage systems of southern Indiana attention is called to the following points:

1. The drainage in the region but thinly covered with drift, as well as in the driftless region, is controlled by the geologic structure.

The drainage (except in the eastern area) is toward the southwest, with the dip of the strata, and is such as would logically develop from a gradual elevation of a land surface, beginning at the east part of the state, and a corresponding recession of the water toward the southwest. The evidence points to the conclusion that the present drainage has developed from such an ancient initial drainage, and the writer believes this to have been the case.

2. The writer is unacquainted with any evidence in southern Indiana that the drainage has ever been toward the north and east.[1]

From above Madison to the southwestern corner of the state the Ohio River cuts more or less directly across successive groups of hard and soft strata. This is the position that would have been occupied by the stream had its course been developed across the groups of strata in question as those strata were gradually raised above the water at the west side of the land mass formed by the Cincinnati Arch, and a corresponding retreat of the water to the west. It is believed that the present course of the Ohio from and below the neighborhood of Madison has been developed from such ancient initial drainage—with many periods of comparative rest, and of activity, of course, corresponding with depressions and elevations of the land surface of the region traversed.

[1] See GERARD FOWKE, "Preglacial Drainage Conditions in the Vicinity of Cincinnati," *The Ohio State Academy of Sciences Special Papers*, No. 3, p. 68 *et seq.* Evidence is produced to show that the Ohio flowed northeastward in preglacial time, from near Madison.

If the preglacial drainage of southern Ohio and southeastern Indiana (the eastern area, of the present discussion) was toward the north and east, as some writers believe, then the watershed between such northeastward drainage and the southwestward drainage of Indiana was the highland formed by the Niagara and Devonian limestones, *i. e.*, the present watershed between the eastern and central drainage areas of southern Indiana.

How far north this watershed may have extended cannot be conjectured, but it probably extended as far north as Clinton county, and east of that county.

3. It is believed that that portion of the state in which the preglacial topography and structure were similar to the present topography and structure of the driftless area had also preglacial drainage systems parallel in a general way with the present drainage systems of the driftless region. This includes most of that portion of the state which lies west of the southwestward dipping Niagara and Devonian limestones.[1]

(By "driftless region" is here meant that region in which it is obvious that the present drainage systems are not controlled primarily by the drift.)

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[1] The drainage through the north end of the central area, or trough — *i. e.*, in the region of Clinton county and northward from there — may have been toward the northwest, so far as the structure is concerned.